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# AN ANALYSIS OF ALTERNATIVE PERIODIC HEALTH EXAMINATION STRATEGIES

Research Contribution 203  
(Revised)

**Center  
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Data from the Armed Forces were investigated to enable inferences as to the benefits and costs of alternative periodic health examination strategies. The periodic health screening program is treated on two levels: first, it is viewed as a production process whose inputs are the frequency of the examinations and the scope of an examination. A standard aggregate production function that captures the technology effect is adapted to the health screening production process, with age as the analogue to technical change, and the parameters of this function are estimated. Then, at a second level, the respective effects of variations in age and variations in the ability of the periodic health screening program to detect illness, upon the rate of serious morbidity in the population, are examined. Implications of this and related studies for policy regarding periodic health examination programs are discussed.

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**CENTER FOR NAVAL ANALYSES**

**Institute of Naval Studies  
Research Contribution 203**

**AN ANALYSIS OF ALTERNATIVE PERIODIC  
HEALTH EXAMINATION STRATEGIES**

**October 1972**  
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**Brian E. Forst**

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### ABSTRACT

Data from the Armed Forces were investigated to enable inferences as to the benefits and costs of alternative periodic health examination strategies. The periodic health screening program is treated on two levels: first, it is viewed as a production process whose output is the ability of the program to detect illness and whose inputs are the frequency of the examinations and the scope of an examination. A standard aggregate production function that captures the technology effect is adapted to the health screening production process, with age as the analogue to technical change, and the parameters of this function are estimated. Then, at a second level, the respective effects of variations in age and variations in the ability of the periodic health screening program to detect illness, upon the rate of serious morbidity in the population, are examined. Implications of this and related studies for policy regarding periodic health examination programs are discussed.



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## AN ANALYSIS OF ALTERNATIVE PERIODIC HEALTH EXAMINATION STRATEGIES

I wish, then, to propose as the only means by which to reach the evil and obtain the good, that there should be instituted, as a custom, a system of periodic examination, to which all persons should submit themselves, and to which they should submit their children.<sup>1</sup>

### 1. Introduction

There is an abundance of conventional wisdom about the importance of preventive medicine in general and of the periodic health examination in particular. The American Medical Association has, since 1922, regularly and officially encouraged physicians to administer periodic health examinations (hereafter, PHE) to persons in the apparent condition of good health.<sup>2</sup> One physician even went so far as to write that failure to search for "unseen enemies" in the human body "is perhaps the most outstanding and incomprehensible piece of stupidity of which the human race is guilty."<sup>3</sup>

Fifty years later, the advice has been toned down a bit, but persists nonetheless. The media continue to remind us of the importance of fighting cancer on a regular basis "with a check-up and a check." A recent editorial in the Washington Post asserts:

Preventive medicine is a simple idea: you visit the doctor before you get sick, rather than after. . . Such logic has been followed by millions who go in for cancer check-ups or heart tests. This makes sense economically--because of the money saved--and medically, because catching a disease early is considerably less demanding on the patient, doctor and hospital than catching it later.<sup>4</sup>

This wealth of common knowledge appears to be absolutely unsupported by empirical evidence. After undertaking an exhaustive literature search of the value of PHE, Siegel concludes that it is "a scientifically unproved preventive medical practice. We do not have conclusive evidence that populations undergoing PHE live longer, better, healthier, or happier because of it, nor do we have evidence to the contrary."<sup>5</sup>

It is the intent of this paper to shed some light on the costs and benefits of alternative PHE programs by investigating data on officers in the U. S. Armed Forces.

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<sup>1</sup> [2].

<sup>2</sup> [5, pp. 2, 4, 5, 16, 56, 61].

<sup>3</sup> [5, p. 6].

<sup>4</sup> [7].

<sup>5</sup> [6, p. 294].

We go about this by addressing two distinct questions. The more fundamental of the two asks how the ability of the PHE program to detect illness early, together with the age of the individual examined, affect the rate of very serious morbidity in the population. The second issue has to do with the respective contributions to the ability of the program to detect illness early made by three different factors: the frequency of the examinations, the scope of an examination, and the age of the individual examined.<sup>6</sup>

## 2. Measures of Costs and Benefits

On the cost side, we take the viewpoint of the Armed Forces, and estimate two components: the value of the medical resources consumed by the PHE and the officer's product lost in the examination process.

One could attempt to estimate the value of medical resources consumed by the PHE in the military by adding the direct personnel costs (in this case, the cost of doctors, medical corpsmen, nurses, and laboratory technicians involved in the periodic examination); the cost of supplies and equipment used; plus a portion of military overhead, medical and otherwise. If this technique were used, appropriate portions of commuted life cycle costs of all the equipment and buildings associated in any way with the PHE would be calculated using estimates of both the expected life of each type of such capital and an appropriate discount rate.

An alternate way of estimating the cost of medical resources, and the method that we employ here, is to assume that the civilian sector is about equally as efficient as the Armed Forces at giving an equivalent PHE, and simply estimate the average price of particular kinds of examinations in private practice. This approach seems preferable partly because it is enormously easier, but primarily because it is likely to produce a more accurate estimate of the true economic cost of the resources consumed.<sup>7</sup>

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<sup>6</sup>

The selection of these factors was constrained by the availability of data. It would have been preferable, for example, to investigate mortality rates in addition to, if not instead of, rates of serious morbidity; but the information on mortality would have been much too costly for us to collect. It would have also been useful to extend the analysis to all servicemen, rather than officers alone; however, the frequency of health examinations for enlisted men is not governed by rules of periodicity as with officers. Rather, enlisted men are examined each time they reenlist, and reenlistment intervals are highly variable and are not recorded in the servicemen's health jackets.

<sup>7</sup>

The difficulties in making an accurate estimate under the first approach are legion. One barrier that stands in the way of estimating the true cost of these resources is the existence of distortions caused by the draft. The pay of doctors in the military is a gross understatement of their actual market value. This also holds for medical corpsmen, although to a lesser degree. Another difficulty stems from the fact that the military's discount rate is distorted by perverse aspects of the Federal appropriation system. Still another lies in estimating the market value of military land, although space consumed by periodic examinations may not be vast.

The second major cost component--productivity lost by officers examined periodically --is extraordinarily difficult to measure. A useful, even if simplistic convention that we employ here is to assume that officers are earning exactly their marginal product, and use officer pay as a proxy for productivity.

### 3. Evidence on Officers in the Armed Forces

Truly rigorous analysis of the effects of altering the frequency of periodic physical examinations requires a carefully controlled experiment. Experiments of this type are exceedingly difficult to perform.<sup>8</sup>

As it turns out, a quasi-controlled experiment of alternative PHE programs has been going on for years--quite unintentionally, however. By the authority of Paragraph 3 of Article 1280--"Physical Fitness"--of Navy Regulations, all Naval and Marine Corps officers were, until the summer of 1971, required to have a physical examination once each year. By similar authority of Paragraph 10-23 of Army Regulation 40-501--"Standards of Medical Fitness"--all Army officers other than aviators are "required to undergo a periodic medical examination during the anniversary months of their birthday ages as follows: 18, 21, 24, 27, 30, 32, 34, 36, 38, 40 and annually thereafter." Army aviators are examined annually.

Hence, if Navy<sup>9</sup> and Army officers had been exactly the same in every way other than the frequency of their physical examination, one could simply observe differences in serious morbidity and infer that the Navy's more frequent examination schedule had such and such an effect upon the following diseases for the following age groups. The extent to which they were not, in fact, exactly the same in every other way can be estimated, since there exist a number of age cells which contain officers who were examined as recently in the Army as in the Navy.

#### 3.1 Disability Retirements List

Each service maintains a list of officers who become sufficiently ill while on active duty to warrant temporary retirement with disability pay, the amount of which depends upon the officer's active duty pay and the degree of severity of his disability. A large random sample of this list in each service as of the proximity of 1 July 1970 served as the primary

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<sup>8</sup> In the first place, controlled experiments on the effects of various intervals between health examinations upon morbidity or mortality generally require long periods of analysis for the effects to materialize. Populations seldom stay put long enough to enable such study. In the second place, if there is sufficient prior evidence to suggest that the study is warranted (i. e., that there may, indeed, be a difference), then there is generally a strong reluctance to have humans serve as guinea pigs in the cohort which receives inferior treatment.

<sup>9</sup> Unless stated otherwise, "Navy" will be used in this paper to include both Navy and Marine Corps. There were not enough observations on Marine Corps officers in this study to justify separate treatment.

source of data for this study. Injury and mental illness were excluded under the presumption that the PHE serves no useful purpose in the prevention of either. The following information was extracted from the medical record of each officer sampled: name, service, service number, sex, date of birth, whether commissioned or warrant, whether or not an aviator, and pertinent information about each illness which qualified the individual for disability retirement--illness identifier code, date of detection, and mode of detection (i.e., whether detected as PHE, entrance physical examination, other physical examination, or sick call).

These data were converted into 50 age-service cells--ages 24 through 48 for Navy and Army. Each of these 50 "observations" reports service (coded as a 0 for Army and a 1 for Navy); age; the number of officers sampled from the disability retirements list in each cell; the number of physicals per officer per year; the estimated average civilian sector price of an average quality examination for this cell, as estimated by a sample of military physicians; the proportion of the total officers in the age-service category who became disabled retirees for reason other than injury or mental illness; and the relative frequency of PHE detection of illness to total detections of illness. The 50 observations are shown in table 1.

### 3.2 The Service Effect

Before putting these data into our model, we consider factors other than the PHE program that could cause the health of Army officers to differ from that of Navy and Marine Corps officers. The first two of these are possible selection biases, and the remaining two factors have to do with conditions of service.

#### 3.2.1 Physical Standards at Entrance

The Navy's physical standards for new officers are outlined in Chapter 15 of the "Manual of the Medical Department," Bureau of Medicine and Surgery (NAVMED Document #P-117). The Army's are written in Chapter 2 of Army Regulation 40-501--Standards of Medical Fitness." A review of these two documents reveals that the most significant differences appear to be more stringent visual acuity requirements in the Navy and a difference in the maximum allowable height (80 inches in the Army, 78 in the Navy). What is perhaps a more important difference is the possibility that, due to somewhat wider fluctuations in officer procurement in the Army than the Navy over time, there may be greater relaxation in the interpretation of these regulations in the Army than in the Navy. There is no strong a priori evidence, however, that this would have any effect upon the incidence of those illnesses for which patients benefit from early detection.

#### 3.2.2 Educational Attainment

Studies which investigate the effect of education upon health generally show an inverse relationship between serious morbidity and mortality rates on the one hand and educational attainment on the other.<sup>10</sup> The Defense Department reports, however, that on 31 December 1965, 76.1 percent of all Army commissioned officers were college graduates, while 75.0 percent of all officers commissioned in the Navy and 72.1 percent in the Marine Corps

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<sup>10</sup> for example, see [3].



TABLE 1  
DATA AGGREGATED FROM THE DISABILITY RETIREMENT LISTS

Age	Navy					Army				
	<u>n</u>	<u>FREQ</u>	<u>SCOPE</u>	<u>MORB</u>	<u>DR</u>	<u>n</u>	<u>FREQ</u>	<u>SCOPE</u>	<u>MORB</u>	<u>DR</u>
24	18	1	\$40.00	.01344	.1111	3	1/3	\$48.00	.00380	.0000
25	10	1	41.50	.00753	.1000	2	1/3	48.00	.00292	.0000
26	11	1	43.00	.01075	.1818	4	1/3	48.00	.01595	.0000
27	6	1	44.50	.00871	.3333	6	1/3	48.00	.02900	.1250
28	5	1	46.00	.00995	.0000	1	1/3	48.00	.02762	.1250
29	7	1	47.50	.01470	.2857	1	1/3	48.00	.00785	.1250
30	1	1	49.00	.00211	.0000	2	1/2	48.00	.01732	.0000
31	7	1	50.50	.01503	.0000	0	1/2	48.00	.01443	.0000
32	9	1	52.00	.02035	.1111	2	1/2	48.00	.01116	.0000
33	4	1	53.50	.01177	.0000	1	1/2	48.00	.00383	.0000
34	4	1	55.00	.00981	.0000	1	1/2	48.00	.02372	.0000
35	5	1	56.50	.01487	.2000	1	1/2	48.00	.00403	.2500
36	5	1	58.00	.01291	.2000	3	1/2	48.00	.01646	.2500
37	6	1	59.50	.01943	.0000	2	1/2	48.00	.02100	.0000
38	3	1	61.00	.00867	.3333	1	1/2	48.00	.00429	.0000
39	6	1	62.50	.01826	.1667	5	1/2	48.00	.03093	.0000
40	8	1	64.00	.03716	.2500	7	1	48.00	.03258	.1429
41	3	1	65.50	.01498	.3333	4	1	49.12	.03087	.5000
42	8	1	67.00	.04206	.0000	2	1	50.25	.01106	.0000
43	4	1	68.50	.02214	.5000	2	1	51.37	.01639	.0000
44	2	1	70.00	.01177	.0000	3	1	52.50	.02893	.0000
45	1	1	71.50	.00626	1.0000	6	1	53.62	.04537	.1667
46	5	1	73.00	.04041	.2000	4	1	54.75	.06519	.2500
47	4	1	74.50	.02896	.0000	2	1	55.87	.03747	.0000
48	6	1	76.00	.04937	.1667	4	1	57.00	.04408	.2500

n = Number of observations per cell.

FREQ = Number of periodic physical examinations given per year.

SCOPE = Civilian sector price of an average quality examination for this cell, as estimated by sample of military physicians.

MORB = Proportion of officers who become retired with serious illness.

DR = Proportion of serious illness cases detected at the periodic examination.

had attained this level of education.<sup>11</sup> We know of no study that suggests that such slight differences in education would cause illness rates to differ perceptibly across the services.

### 3.2.3 Environment

Various regions and conditions of assignments are likely to have different effects upon health. One might reasonably expect, for example, that officers aboard a ship are subjected to higher density living conditions than other officers. To whatever extent this is true, the Navy might be justified in conducting a more frequent or more intensive (or both) screening program for infectious diseases among officers. Being isolated from the land for long periods of time might, on the other hand, work in the opposite direction, so that one might expect Navy officers to be less exposed to certain other kinds of infections. Most other Naval officers and virtually all the Marine Corps officers serve in assignments very similar to Army officers. On balance, then, it is not clear that the environmental differences are sufficiently great to invalidate conclusions about the effects of the periodic health examination.

### 3.2.4 Proclivity to Report to Sick Call

Incidence rates and severity of certain illnesses may be different across the services if, for whatever reason, officers with given levels of pain or other symptoms are more inclined to report to a doctor in one service than another. The only a priori evidence of this type that comes to mind has to do with the effect of a more frequent physical on the behavior of Navy officers to voluntarily report ill. In the first place, one might expect Navy officers to put off reporting illness because of a false sense of complacency, having been examined and found well more recently, on average. In the second place, one might expect a Navy officer to put off going to sick call because it is more likely that he will soon have a periodic physical examination. These effects are unlike the other potential sources of bias, however, because they are tied to the frequency of the physical examination, which is directly in question here.

We noted in the introduction to Section 3 that if there were a strong service effect apart from differences in respective PHE programs, we would see it by looking at the rates of serious morbidity for Army and Navy officers in the age class 40 through 48, since officers of these ages in both major branches of service are in similar PHE programs. In fact, we observe that 2.8 percent of all Navy and Marine Corps officers aged 40 through 48 become disability retirees annually for reasons other than injury and mental illness; for the Army counterpart the rate is 3.1 percent.

Hence, we have both a priori and empirical evidence that induces us to reject the hypothesis that a strong service effect prevails apart from differences in the respective PHE programs.

### 3.3 The PHE as a Means of Reducing Serious Morbidity

What light is shed upon the two principal questions by the data? Let us first examine the effect of altering the ability of a PHE program to detect illness upon the incidence of serious morbidity, since this is surely the more important of the two questions.

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<sup>11</sup> [8, p. 36].

To isolate the effect of the overall quality of the PHE program upon serious morbidity, we investigate first our suspicion that age will be a driving force behind variations in serious illness. This is tentatively confirmed by the regression result

$$(1) \quad \text{MORB} = -.02297 + .00119 \cdot \text{AGE} \quad r^2 = .3851, \\ (.00022)$$

where MORB is the probability that an officer becomes sufficiently ill in a given year to qualify for disability retirement, and where the number in parentheses is the standard error for the coefficient immediately above it. In the absence of other forces working through the age variable,  $r^2 = .3851$  means that age "explains" 38.5 percent of the total variation we observe in morbidity.

Then, letting DR (short for detection rate) denote the ratio of PHE detections to total detections of serious illness, we observe

$$(2) \quad \text{MORB} = -.02380 + .00124 \cdot \text{AGE} - .00787 \cdot \text{DR}, \quad r^2 = .3952. \\ (.00023) \quad (.00888)$$

From this result we infer that age and detection rate explain 39.5 percent of the observed variation in morbidity, age being the predominant of the two independent variables over the range of the observations. That the age coefficient is essentially unaltered by the introduction of the detection rate into the right hand side (hereafter, r. h. s.) suggests that collinearity (i. e., mutual dependence among the two r. h. s. variables) is not substantial here; this is further supported by the fact that the coefficient of correlation between these two variables is  $-.261$ .

We cannot infer from this result that there is an unmistakable link between DR and MORB. The t-value for the DR coefficient in (2) is not large ( $-.00787/.00888 = -0.8854$ ); if, in fact, DR had no effect whatever upon MORB, a negative t-value this large would be observed about one-fifth of the time due to the random variation that occurs in taking samples of 50 observations.

It must be noted that DR measures the ability of the PHE program to detect serious illness. We might allege that a really good early detection program ought to prevent an officer from ever qualifying for disability retirement at the time of his PHE, so that here the numerator of the DR measure is zero. I assert that no such a program, if indeed one that good were at all possible, could conceivably be at work in the Armed Forces, given the frequency schedule in existence. Even if it were, a program that good might well produce a zero denominator for DR, too, so that DR is not zero in this case. And in the absence of a PHE program, DR must be zero. A reasonable argument that explains how DR might decline in any interval as either the frequency or scope (or both) of a physical exam increases has not yet revealed itself to me.

#### 3.4 Optimal Scope and Frequency Input Combinations

It remains to establish the scope and frequency combinations that are in some sense best. If we knew the precise functional form and parameters of:

$$(3) \quad \text{MORB} = f(\text{AGE}, \text{SCOPE}, \text{FREQ}, \dots)$$

and (4)  $DR = f(AGE, SCOPE, FREQ)$ ,

then, given the relationship suggested by (2), minimizing (3) subject to a budget constraint would be equivalent to maximizing (4) subject to the constraint; i.e., optimal SCOPE and FREQ ought to be unique. However, since scope and frequency directly affect the detection rate and only indirectly affect serious morbidity, it seems preferable to work with (4) rather than (3). Specifically, except for a random error component (which, because of the small cell sizes, turns out to be large here), we might reasonably expect scope, frequency, and age to be the sole determinants of the detection rate; we would certainly not expect them to be the sole determinants of serious morbidity.<sup>12</sup>

We next select a functional form for (4). The simple linear form must be rejected on the grounds that scope and frequency are not perfect substitutes in the production of illness detection--they are complements, as well.

An early form of the production function specifically designed to account for technological progress is given by<sup>13</sup>

$$(5) \quad q = A \cdot e^{\beta_1 \cdot t} \cdot L^{\beta_2} \cdot K^{\beta_3},$$

where  $q$  is an index of aggregate output,  $A$  is a scale parameter,  $e^{\beta_1 \cdot t}$  is an efficiency component intended explicitly to measure change in technology, and  $L^{\beta_2}$  and  $K^{\beta_3}$  are the standard labor and capital input components, with elasticities of production with respect to labor and capital  $\beta_2$  and  $\beta_3$ , respectively.

We adapt (5) to the health screening production process by writing

$$(6) \quad 1 + DR = \alpha_0 \cdot e^{\alpha_1 \cdot AGE} \cdot SCOPE^{\alpha_2} \cdot FREQ^{\alpha_3}.$$

It is tempting to use simply  $DR$  as the left-hand side variable; however, to do so poses a problem: A distinct advantage of the multiplicative aspect of (6) is that the expression

<sup>12</sup> For the curious reader, we present the result

$$MORB = -.01793 - .00022 \cdot SCOPE - .00139 \cdot FREQ + .00142 \cdot AGE,$$

(.00026)                      (.00685)                      (.00033)

with  $r^2 = .3962$ . This result should not be taken very seriously, both for the reason cited in the text and because of the linearity assumption. For example, it predicts that for 24-year old officers a \$75 physical examination given not more than once each three years will produce negative morbidity. Less than zero morbidity, of course, defies interpretation.

<sup>13</sup> According to Brown [1, pp. 110-112], this form was first used by Tinbergen, and subsequently by Aukrust, Niitamo, and others.

is linear when expressed in logarithmic form, thereby simplifying the regression computation. Note, however, in table 1 that several cells contain the sample observation  $DR = 0$ . Since the log of zero is undefined, an adjustment of some sort is necessary. We reject using  $1 - DR$  as the adjustment in the left-hand side because one cell contains the observation  $DR = 1$ .

There is at least some superficial attractiveness to treating age as an analogue to technology, as we have in (6), but little is served in making much of the similarities here.

Weighting each of the observations reported in table 1 by  $n \cdot DR \cdot (1 - DR)$ , as is customary when the dependent variable of regression is a proportion, produces the following least squares estimate of the parameters of (6):

$$(7) \quad 1 + DR = e^{0.00259} \cdot e^{0.00307 \cdot AGE} \cdot SCOPE^{0.02561} \cdot FREQ^{0.03649}$$

$$(\quad .00267) \quad (\quad .11402) \quad (\quad .04891)$$

$$r^2 = .1321$$

The budget equation that constrains the maximization of  $DR$  is:

$$(8) \quad C_{AGE} = (FREQ_{AGE}) (SCOPE_{AGE} + MPL_{AGE}),$$

where  $C_{AGE}$  is the annual budget per officer for a particular age group, and  $MPL_{AGE}$  is the marginal product lost while that officer is away from duty because of the PHE. This formulation follows the discussion in Section 2.

Note that this budget constraint is nonlinear. The unfortunate feature about the system produced by (7) and (8) is that for all positive  $AGE$ ,  $C$ , and  $MPL$ ,  $DR$  is maximized when  $SCOPE$  is infinitely large and  $FREQ$  is correspondingly small. This results from the fact that (7) and (8) are non-intersecting hyperbolas in the positive quadrant of the  $(SCOPE, FREQ)$ -plane that converge only as  $SCOPE$  grows large.

Hence, in lieu of optimizing, we must be content to estimate through (2) and (7) the cost and morbidity effects of several alternative scope-frequency strategies. The strategies we shall consider are in or near the range of observations that underlie the predictions. The estimates of annual morbidity and cost are shown in table 2.  $MPL_{AGE}$  is presumed to be \$20 for 24-year olds, \$30 for 36-year olds, and \$40 for 48-year olds. This is approximately equivalent to assuming that the Navy loses about four hours of an officer's product while he is tied up with the PHE (including traveling and administrative processing time) and that an officer's pay very nearly reflects his marginal product.

The table 2 estimates say that for all ages observed, a shift from the strategy of giving a PHE worth \$25 once every three years to that of giving one worth \$100 annually can be expected to prevent about seven officers out of each 10,000 from joining the rolls of disabled retirees annually. The expected cost to the services of such a shift is estimated to be over \$1 million for each 10,000 officers screened, or over \$150,000 for each officer saved from disability.

TABLE 2  
ESTIMATED MORBIDITY/COST CONSEQUENCES  
OF ALTERNATIVE FREQUENCY AND SCOPE STRATEGIES  
FOR OFFICERS AT AGES 24, 36, AND 48

	<u>\$25</u>	<u>Scope</u> <u>\$50</u>	<u>\$100</u>
24-year olds:			
Frequency:			
Triennial	.00512/ \$15.00	.00496/ \$23.30	.00480/ \$40.00
Biennial	.00498/ \$22.50	.00482/ \$35.00	.00466/ \$60.00
Annual	.00476/ \$45.00	.00459/ \$70.00	.00443/ \$120.00
36-year olds:			
Frequency:			
Triennial	.01971/ \$18.33	.01955/ \$26.67	.01938/ \$43.33
Biennial	.01958/ \$27.50	.01941/ \$40.00	.01924/ \$65.00
Annual	.01934/ \$55.00	.01917/ \$80.00	.01900/ \$130.00
48-year olds:			
Frequency:			
Triennial	.03430/ \$21.67	.03413/ \$30.00	.03396/ \$46.67
Biennial	.03416/ \$32.50	.03399/ \$45.00	.03381/ \$70.00
Annual	.03391/ \$65.00	.03374/ \$90.00	.03356/ \$140.00



To assess whether the services should make such a shift, we compare the cost of making the shift with the sum of the present value of the stream of the retirement benefits plus the cost of replacing officers retired with disability.<sup>14</sup> We shall assume a 10 percent discount rate, an average annual disability retirement pension of \$2,000, and an average pension term of 30 years; the present value of such a stream of payments is less than \$19,000 per officer. Accordingly, the replacement cost per officer would have to exceed \$130,000 to justify the shift. It is doubtful that the actual replacement cost is as much as one-fifth of this amount.

#### 4. Summary and Conclusion

If you accept the production function form given by (6), the data on officers in the U. S. Army and Navy suggest that frequency, scope, and age combine in a manner described by (7) to produce DR, which is an index of the ability of a periodic health examination (PHE) program to detect illness. The effect that varying DR has, in turn, upon the probability that an officer will become sufficiently ill to qualify for disability retirement, for reasons other than injury or mental illness, is shown in (2) to be slight. Just how slight this effect is is demonstrated by the sensitivity analysis presented in table 2. Within the range of observations that underlie the estimates, we see that large changes in the cost of a PHE program are associated with small changes in serious morbidity among officers in the Armed Forces.

These conclusions are incorrect to the extent that there really is a strong service effect (i. e., that there are effects at work other than different frequencies and scopes between the Navy and Army), to the extent that the functional form expressed in (6) is inappropriate, to the extent that DR is not closely related to the ability of a PHE program to detect illness early, or to the extent that random error played a strong role. This paper presents both a priori and empirical evidence to support the claim that the non-random errors are likely to be small.

Even if the conclusions are correct, however, it remains a possibility that while the PHE program has no substantial effect upon serious morbidity, it does have a useful effect upon the mortality rate or upon mild-to-moderate morbidity. I am inclined to believe that the effect upon serious morbidity would resemble the effects upon mortality and mild morbidity.

A related criticism of these results is that mortality rate would have been a better output measure than morbidity rate because a successful early detection program ought to increase the known incidence of disease. As indicated earlier, we would have investigated effects upon death rates if such data had been more readily available. The important point to be made here, however, is that the morbidity data we used are valid for our purpose,

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<sup>14</sup>

We ignore the disutility cost to the officer associated with disability retirement, on the grounds that all officers have already incurred this cost upon signing the service contract. Agreement to this contract implies that the officer receives sufficient compensation from the services to cover this risk.

since we limited the observations to very serious illness. Certainly, an early detection program might increase total morbidity; but if the program is truly successful, it ought to reduce the probability that a person in the program becomes seriously ill.

The only empirical work I know of that investigates the value of periodic screening examinations in reducing death rates is the Framingham Study, conducted by the Public Health Service.<sup>15</sup> It was intended primarily as a long-term analysis of cardiovascular illness. Part of the study involved a well-controlled experiment which examined the effect of a PHE program upon mortality rates (i. e., total mortality rather than cardiovascular-related mortality). The data indicated mixed effects by age and time in PHE program.<sup>16</sup>

A notable advantage of the Framingham Study is that it dealt with a civilian population. It is certainly appropriate to exercise caution in extending the results of this paper, dealing as it does exclusively with officers in the Armed Forces, to more general populations, even though the conclusions are not inconsistent with those in [4].

What is absolutely clear is that the usual rhetoric about the value of periodic screening programs is inflated well beyond a level which existing data support. My own opinion at this time is that the PHE does lead to early detection, and that early detection is sometimes useful in averting more serious illness; in other instances, it provides information which may be misused by medical professionals.

Until more revealing data are brought forth, then, individuals and institutions such as the Armed Forces are left to determine both their PHE budgets and, given the budgets, their frequency-scope tradeoffs somewhat arbitrarily. My hope is that this paper will reduce the arbitrariness that has heretofore existed.

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<sup>15</sup> [4].  
<sup>16</sup>

A principal investigator in this study informed me that these results were not published mainly because it was felt that they would have an adverse effect on a program to encourage periodic physicals.



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